

The invention claimed is:

1           1. A method of encoding information symbols for multiple antennae transmission  
2 comprising the steps of:  
3           generating a code matrix  $B_0$  ;  
4           generating a transformation matrix L where; and  
5           combining the code matrix  $B_0$  with the transformation matrix L to obtain a result B for  
6 controlling the amount of beamforming relative to the amount of orthogonal coding in signals  
7 transmitted from the multiple antennae.

1           2. The method of claim 1 wherein the transformation matrix L is a matrix such that,  
2 when the conjugate transpose of L is multiplied by L generates a desired correlation matrix  $\Phi$  .

1           3. The method of claim 2 wherein the code matrix  $B_0$  is orthogonal.

1           4. A method of encoding information symbols for multiple antennae transmission  
2 comprising the steps of:  
3           generating a code matrix  $B_0$  ;  
4           generating a transformation matrix L where L satisfies the relationship  
5 where  $\Phi = L^H L$  is a desired correlation matrix  $\Phi$  ; and  
6           combining the code matrix  $B_0$  with the transformation matrix L to obtain a result B for  
7 controlling the amount of beamforming relative to the amount of orthogonal coding in signals  
8 transmitted from the multiple antennae.

1           5. The method of claim 4 wherein the desired correlation matrix is comprised of at least  
2 one correlation parameter  $\lambda$  .

1           6. The method of claim 5 wherein the transformation matrix L is the matrix square root  
2 of the desired correlation matrix  $\Phi$  .

1           7. The method of claim 4 wherein blocks of symbols of a serial data stream of user data  
2 are encoded with an orthogonal code to form code matrix  $B_0$  .

1           8. A method of generation signals for transmitting from at least two antennae of a  
2 wireless communications system comprising the steps of:  
3           feeding a stream of incoming information symbols to an encoder;  
4           feeding a signal representative of a beamforming weight parameter to the encoder to  
5 modify the stream of information symbols;  
6           feeding a code correlation parameter ( $\lambda$ ) to the encoder to control the proportion of  
7 orthogonal coding relative to beamforming of the stream of information symbols that are to be  
8 transmitted; and  
9           feeding the stream of information symbols modified by the code correlation parameter to  
10 at least two antennae for transmission.

1           9. The method of claim 8 wherein the code correlation parameter determines the  
2 correlation of the encoded signals to the different antennae.

1           10. The method of claim 9 wherein the signal representative of the beamforming weight  
2 parameter represents a complex number having a magnitude and a phase.

1           11. The method of claim 9 wherein the signal representative of the beamforming weight  
2 parameter is of a real number of the phase of the beamforming weight parameter.

1           12. The method of claim 11 wherein the code correlation parameter is of a real number  
2 can vary between a first value and a second value.

1           13. The method of claim 12 wherein one of the values represents orthogonal coding  
2 with no beamforming and the other value represents beamforming with no orthogonal coding, and  
3 intermediate values represent a combination of orthogonal coding and beamforming.

1           14. The method of claim 9 wherein, in a duplex communication system having a forward  
2 and reverse link, the code correlation parameter is determined from signals received on the  
3 reverse link.

1           15. The method of claim 14 further comprising the step of determining a channel  
2 correlation coefficient ( $\rho$ ) from the signals received on the reverse link.

1           16. The method of claim 15 wherein the channel correlation coefficient ( $\rho$ ) is a complex  
2 number from which the magnitude component and not the phase component is used to determine  
3 the code correlation parameter  $\lambda$ .

1           17. The method of claim 14 wherein the channel correlation coefficient is an estimate of  
2 auto-correlation coefficient of channel gain from an antenna for a fixed time delay.

1           18. The method of claim 17 wherein the delay is determined by the difference between  
2 the time at which feedback information is transmitted on the reverse link to the time at which the  
3 beamforming weight parameter computed using that information is applied by the forward link  
4 transmitter.

1           19. The method of claim 18 wherein the delay is equal to the time difference multiplied  
2 by the ratio of carrier frequencies on the reverse and forward links.

1           20. The method of claim 8 wherein the symbol signal transmitted by each antenna at  
2 each symbol time is the sum of one or more signals, each of which is proportional to the product  
3 of one of the incoming symbols and their complex conjugates and their negations and their  
4 negations of their complex conjugates, with a number that is determined by lambda.

1           21. A method of forming a signal comprising the steps of:  
2 obtaining at least two component signals;  
3 multiplying a first component signal by a first complex number to obtain a first signal;  
4 multiplying a second component signal by a second complex number to obtain a second  
5 signal;  
6 wherein the phases of the first and second complex numbers are unequal; and  
7 subtracting the second signal from the first signal to obtain a first composite signal for  
8 transmission by a first antenna element during a first transmit period.

1           22. A method of forming signals for transmission from an antenna element during two  
2 transmit periods comprising the steps of:  
3 obtaining at least two component signals for each transmit period;  
4 multiplying a first component signal by a first complex number to obtain a first signal;

5 multiplying a second component signal by a second complex number to obtain a second  
6 signal;  
7 wherein the phases of the first and second complex numbers are unequal;  
8 subtracting the second signal from the first signal to obtain a first composite signal for  
9 transmission by the first antenna element during a first transmit period;  
10 multiplying a third component signal by a second complex number to obtain a third  
11 signal;  
12 multiplying a fourth component signal by a first complex number to obtain a fourth  
13 signal; and  
14 adding the third signal to the fourth signal to obtain a second composite signal for  
15 transmission by the antenna element during a second transmit period.

23. A method of forming signals for transmission from two antenna elements during two  
transmit periods comprising the steps of:  
obtaining at least two component signals for each antenna for each time interval;  
multiplying a first component signal by a first complex number to obtain a first signal;  
multiplying a second component signal by a second complex number to obtain a second  
signal;  
wherein the phases of the first and second complex numbers are unequal;  
subtracting the second signal from the first signal to obtain a first composite signal for  
transmission by a first antenna element during a first transmit period;  
multiplying a third component signal by a second complex number to obtain a third  
signal;  
multiplying a fourth component signal by the first complex number to obtain a fourth  
signal;  
adding the third signal to the fourth signal to obtain a second composite signal for  
transmission by the first antenna element during a second transmit period;  
multiplying the first component signal by a third complex number to obtain a fifth signal;  
multiplying the second component signal by a fourth complex number to obtain a fourth  
signal;  
wherein the phases of the third and fourth complex numbers are unequal;  
adding the third signal to the fourth signal to obtain a third composite signal for  
transmission by the second antenna element during the first transmit period;

22 multiplying the third component signal by the fourth complex number to obtain a fifth  
23 signal;  
24 multiplying the fourth component signal by the their complex numbers to obtain a sixth  
25 signal;  
26 wherein the fifth and sixth complex numbers are unequal; and  
27 subtracting the fifth signal from the sixth signal to obtain a fourth composite signal for  
28 transmission by the second antenna element during the second transmit period.

1 24. The method of claim 23 wherein the component signals are determined by at least  
2 one incoming information symbol and at least one of the component signals is related to a code  
3 correlation parameter.

4 1 25. The method of claim 24 wherein each component signal is related to at least one of  
5 2 two information symbols, or their negations, or their complex conjugates or the negations of their  
6 3 complex conjugates.

7 1 26. A method of forming a signal comprising the steps of:  
8 2 obtaining at least two component signals;  
9 3 applying a first phase to a first component signal to obtain a first signal;  
10 4 applying a second phase to a second component signal to obtain a second signal;  
11 5 wherein the first and second phases are unequal; and  
12 6 combining the second signal and the first signal to obtain a first composite signal for  
13 7 transmission by a first antenna element during a first transmit period.

1 27. A method of forming signals for transmission from an antenna element during two  
2 transmit periods comprising the steps of:  
3 obtaining at least two component signals for each transmit period;  
4 applying a first phase to a first component signal to obtain a first signal;  
5 applying a second phase to a second component signal to obtain a second signal;  
6 wherein the first and second phases are unequal;  
7 combining the second signal and the first signal to obtain a first composite signal for  
8 transmission by the first antenna element during a first transmit period;  
9 applying a second phase to a third component signal to obtain a third signal;  
10 applying a first phase to a fourth component signal to obtain a fourth signal; and

11 combining the third signal and the fourth signal to obtain a second composite signal for  
12 transmission by the antenna element during a second transmit period.

1 28. A method of forming signals for transmission from two antenna elements during two  
2 time intervals comprising the steps of:

3 obtaining at least two component signals for each antenna for each time interval;

4 applying a first phase to a first component signal to obtain a first signal;

5 applying a second phase to a second component signal to obtain a second signal;

6 wherein the first and second phases are unequal;

7 combining the second signal and the first signal to obtain a first composite signal for  
8 transmission by a first antenna element during a first time interval;

9 applying the second phase to a third component signal to obtain a third signal;

10 applying the first phase to a fourth component signal to obtain a fourth signal;

11 combining the third signal and the fourth signal to obtain a second composite signal for  
12 transmission by the first antenna element during a second time interval;

13 applying a third phase to the first component signal to obtain a fifth signal;

14 applying a fourth phase to the second component signal to obtain a fourth signal;

15 wherein third and fourth phases are unequal;

16 combining the third and fourth signals to obtain a third composite signal for transmission  
17 by the second antenna element during the first transmit period;

18 applying the fourth phase to the third component signal to obtain a fifth signal;

19 applying the third phase to the fourth component signal to obtain a sixth signal; and

20 combining the fifth signal and the sixth signal to obtain a fourth composite signal for  
21 transmission by the second antenna element during the second time interval.